ABSTRACT

To meet the exceedingly rigorous demands of industrialised societies there is an emergent need to reduce or control friction and wear of materials. The new coating and treatment methods are developed to mitigate friction and wear losses and to improve the material performance in specific working conditions. There are many advanced coating deposition methods are available such as vapour deposition, electroplating, thermal spray and so on. Among these advanced deposition techniques, thermal spray is one of the popular technique. Among the various thermal spraying techniques, plasma spraying technique has attracted particular attention for its extremely high processing temperature.

A material such as molybdenum is often sprayed on steel substrate in order to exploit their surface characteristics. Plasma sprayed Molybdenum (Mo) coatings are preferred for automotive, aerospace, pulp and paper industries due to their exceptional wear resistance properties like superior hardness, chemical stability, and refractory character. On the other hand, the operational properties of plasma sprayed molybdenum coating depend on its structure, phase composition, uniformity of microstructure and porosity. The uniformity of microstructure and porosity in plasma sprayed coating is largely affected by size of the powder particles, coating thickness and post treatment on coated surfaces.

Two types of Mo coatings were deposited on AISI 1020 steel substrate, one is with particle size of 15µm-40µm (Type I) and other one is of 40µm-90µm (Type II) using plasma spraying technique. The plasma sprayed Molybdenum coatings with different coating thicknesses (100, 200, 300 and 400µm) were deposited on steel substrate.
The dry sliding wear tests were performed on a pin-on-disc apparatus to evaluate the influence of powder particle size on wear characteristics. The variation of volume loss with applied load, sliding speed and sliding distance were monitored. The results shown that the type I sprayed coating exhibits better wear resistance. Dry sliding wear testing was supported by metallographic examination for the identification of wear mechanism. It was verified that the wear of coating is dominated by fracture of splats, crack propagation, de-lamination and plowing.

The experimental results indicated that the porosity of coating was increased with increase in coating thickness. The increase in coating thickness also resulted in decreased micro hardness. The influence of coating thickness on wear resistance was studied by pin on disk wear test rig. The wear test results demonstrated that, as the coating thickness increases the wear resistance of the coating decreases. In this study, the plasma sprayed thin coating with thickness of 100μm possesses the lowest porosity, the highest hardness and better wear resistance.

The porosity is widely considered as the main cause for the low mechanical properties and wear performance of plasma sprayed coating. Therefore, post treatments like electro-deposition and laser remelting are used to fill the pores and cracks of plasma sprayed coating. The electro deposition of nickel has been used to seal the open pores and micro cracks of the plasma sprayed molybdenum coating.

The experimental results showed that porosity of coating was decreased whereas microhardness increased by sealing. It is observed that electro deposition of Ni is a promising sealing treatment for sprayed coating. The influence of sealing on wear resistance of plasma sprayed molybdenum coating was investigated by pin on disk wear test rig. The sealed plasma sprayed coating exhibits a better wear resistance as compared to the unsealed coating.
Laser remelting is another post treatment used to eliminate the open pores and micro cracks of the plasma sprayed molybdenum coating. The experimental results demonstrated that the porosity of coating was decreased and micro hardness was improved by laser remelting. The influence of laser remelting on wear volume loss of plasma sprayed Mo coating was studied. The laser remelted plasma sprayed Mo coating exhibits better wear resistance as compared to untreated plasma sprayed Mo coating.

The thermal properties of the surface beneath the impinging particles changes as coating builds up and the lamella cooling rate is expected to vary accordingly. The change in cooling rate alters the properties of the underlying material and at the interface. Due to change in lamella cooling rate, the microhardness of subsurface decreases across the cross sectional depth.

In dry sliding wear behaviour, the wear mechanism and wear volume loss mainly depend on the applied load, sliding speed, sliding distance. Hence, the statistical analysis is used to determine factors influencing on dry sliding wear behaviour of plasma sprayed Mo coating, sealed plasma sprayed Mo coating and laser remelted plasma sprayed Mo coating. The response surface methodology (RSM) is used to study the effects of wear process parameters on wear volume loss. The experiments were planned as per Central Composite Design (CCD).

In the case of untreated plasma sprayed coating, the investigation revealed that the applied load was the most dominant factor affecting the wear volume loss of the coating. The sliding speed and interaction effects can be considered as the next important parameters influencing the volume loss. The empirical relationship was established using RSM to predict the volume loss of the untreated pins. The study also revealed that the applied load was the most predominant factor affecting the volume
loss of the coating of sealed plasma sprayed Mo coating. The sliding speed is the next most important parameter influencing the volume loss. The empirical relationships were established using RSM to predict the volume loss of the sealed sprayed coatings.

The applied load was the most dominant factor affecting the volume loss of the coating in the laser remelted plasma sprayed Mo coating. The sliding speed, sliding distance and interaction effects are considered as the next important parameters influencing the volume loss. The empirical relationships are also established for the laser remelted sprayed coating to predict the volume loss.

Keywords: Plasma spray, Electro deposition, Sealing, Wear, Coating thickness, Molybdenum coating, Porosity, Laser re-melting